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THE IDENTIFICATION OF POLLEN FROM SO-CALLED "HAY FEVER" PLANTS

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Pollen grains have been the subject of investigation since the earliest days of microscopical examination of plants. References concerning them may be found as early as the end of the seventeenth century, probably the first reference on this subject being that of Marcello Malpighi (1686) in his famous work 'Anatome Plantarum.' Figure 188, on plate 31, shows drawings of pollen grains of a lily which prove the accuracy of observation of the author. In the accompanying description Malpighi says: "* * * Stamineos loculos, globulorum congerie, quasi atomarum, turgere diximus: Hi diversè configurantur, et colorantur, frequentérque luteum sapiunt colorem, ut in lilio, rosis, et limoniis malis; albescunt verò, diaphaníque ferè sunt in malva, et plantagine. Diversâ pariter donantur figurâ *in lilio croceo, montano albo.* * * *."

From Malpighi up to the beginning of the nineteenth century many references and descriptions of pollen grains are found. Grew pointed out the polymorphism of the pollen grains. Geoffroy spoke of the constancy of size and shape within the species; Needham observed the changes of pollen grains in water preparation, etc. Very correct drawings of pollen grains appear in Purkinje's (1830) work, where the natural classification of plants is attempted and the pollen grains of each group of plants shown. Von Mohl (1835) gives a very complicated and artificial classification of pollen grains based on different marks of identification. An exhaustive citation of the literature from the time of Malpighi is to be found here. Smith ('76) described and drew the pollen grains of a number of plants, and Anderson-Henry ('76) described the pollen grains of two species of *Fuchsia* in connection with remarks about their hybridization. Edgeworth ('77), Hansgirg ('97), and others made the morphology and anatomy of pollen grains the subject of special investigation, but these authors discussed chiefly European or greenhouse plants which have no direct bearing on the subject in question.

Later there were published a number of papers dealing with the pollen of plants, in which especial attention was paid to so-called "hay fever plants." Among these may be mentioned Scheppegrell's ('22) book, in which he gives a very exact description of the most important hay-fever plants and their pollen. The work is supplemented by many photographs of both the plants and the pollen grains and is certainly of great assistance in the identification of the same. Of some value in identifying pollen grains of hay-fever plants may be mentioned the work of Pope ('25) Koessler and Durham ('26), Waring ('26), Wodehouse ('26), and a report published by the Arlington Chemical Company ('25). Especially in Miss Pope's paper are pollen shapes described, as well as markings, size, color, stickiness, and other characters of importance.

Because of the demand from physicians for a more accurate and definite method than existed for the identification and occurrence of pollen in the vicinity of St. Louis, there was begun in the graduate laboratory at the Missouri Botanical Garden investigations of the pollen of some fifty-five plants regarded as responsible for hay fever. The investigations have been carried on along morphological and microchemical lines for the purpose of devising a key for the identification of pollen grains which occur in the respiratory organs. The results of this work are given herewith in synoptical tables and in a key which it is hoped may be of some help to botanists and medical men having occasion to identify pollen grains. Attention should be called to the fact that the reactions given may not be typical for pollen grains taken from the respiratory organs or the mucous membrane. It is certain that changes occur in the chemical composition of pollens during their contact with such parts of the body and therefore the chemical reactions noted may be of little or no value under such circumstances. For this reason two different keys have been elaborated; one based on morphological characters and the occurrence of starch, and the other in the form of synoptical tables both morphological and chemical, for the more accurate identification of fresh material.

Methods

The pollen was either taken from mature flowers and tested the same day, or branches with the ripe flower buds were placed in the incubator until the buds opened, when the fresh pollen was examined. All mounts were made in water. After determining the size and shape of the pollen grains they were stained with "Acid Nigrosine" to determine the number of pores and the presence or absence of lids, after which the other chemical tests were applied.

In all cases the reagent was added in small quantities to the water mounts, except where the pollen had to be tested directly in the reagent in question (i. e., Millon's reagent). Here strong chemicals, such as concentrated acids or lyes, were added drop by drop to avoid a too rapid reaction. In every case the reactions were watched for a long time, or repeated. Tests made from dried herbarium material after it had been kept for years showed that it is possible to identify pollen grains morphologically, the size, shape, and even the number of pores being readily determined. It was not, however, found possible to apply chemical tests to dried pollen, since practically none of the reactions occurring on fresh material took place on the dried specimens.

All investigations and microchemical tests were made with a Zeiss microscope, objective "D" and "ocular No. 3."

SHAPE

The most common shapes of the pollen grains investigated were either spherical or elliptical. Tetrahedral and polyhedral grains also occurred, these outlines being modifications of a sphere caused by the pores producing an angular surface. Mounted in water these shapes are especially distinct, due to the difference in swelling of the pollen wall and the pores.

The pollen of *Pinus austriaca*, like that of most of the conifers, is characterized by the presence of two sac-like projections. These air-sacs are apparently nothing more than the enlarged covers of the pores, the grain itself being typically elliptical (see "Acid Nigrosine" below).

SIZE AND COLOR

The prevailing size of the pollen grains examined varied from 15 to 40 μ in diameter. A few were larger, such as *Ailanthus glandulosa*, 20–50 μ, *Pinus austriaca* (without air-sacs), 40–55 μ, *Taraxacum officinale*, 35–50 μ, *Polygonum persicaria*, 48–70 μ. For each species the size of the pollen grains is constant within the limit given.

The prevailing color of the pollen grains investigated was yellow; in a few cases, noted in the tables, a brown, gray-yellow, or greenish yellow color occurred. The color is of no diagnostic significance, however, and no use is made of it in the key.

SURFACE MARKINGS

Surface markings are important in distinguishing pollen grains, especially if the pores or the thinner places in the pollen wall are considered. Even ignoring the pores, the pollen surfaces of the different species show marked differences. While many are smooth, others have a spiculated or warty surface with spines of different kinds and shapes, with irregular protuberances, reticulations, oil drops, etc.

When the pores are not distinctly visible, they can be brought out more distinctly by certain acids. Reference to such reactions will be found in the synoptical tables. In general, two kinds of pores may be distinguished, large ones and very fine ones, but occasionally there may be a combination of both sizes, so that the pollen may be classified under one of three heads. The large pores may be covered with a distinct lid or closed only with a very delicate membrane, whereas the fine pores are closed with the delicate membrane only. Consequently, according to the nature of the pore covering, a different effect is obtained by treating with certain chemicals or stains. Many of the well-known stains were tried, but no single one was satisfactory for the different pollens. Therefore there was devised a combination of acetic acid and nigrosine, described later under the heading "Acid-Nigrosine," which gave satisfactory results in all cases.

THE EFFECTS OF DIFFERENT REAGENTS ON POLLEN GRAINS

Pollen grains have been tested with a series of chemicals and stains commonly used in botanical microtechnics. Some of the reactions are listed in the synoptical tables. During the course of this investigation it has been ascertained that only the tests with three mineral acids (sulphuric, nitric and hydrochloric acids), three alkalies (ammonia water, sodium hydroxide, and potassium hydroxide), and iodine solutions (iodine water and "Lugol's solution") gave reactions which are of any value for identification. Of staining solutions, safranine, fuchsine, methylene blue, gentian violet, and neutral red have been used. The tests with mineral acids gave in general color reactions. In some cases, mentioned in the tables, the appearance of the whole structure or of parts of it was changed.

In concentrated sulphuric acid the contents and the intine are dissolved; usually the dissolved contents swell and creep out through the pores, or when the swelling takes place very rapidly the pollen grains burst. The color reactions in sulphuric acid are mostly confined to the wall. In cases where the contents showed a reaction different from that of the pollen wall it has been mentioned in the tables.

Artemisia absinthium, *Aster novae Angliae*, and *Helianthus annuus* have, either in the contents or in the oil drops occurring on the surface, certain yellow or orange-colored pigments. These pigments gave in concentrated sulphuric acid the typical reaction of lipochromes; the natural yellow color turned into green and finally into dark blue, and the contents and oil drops showed

RELATIVE TIME AT WHICH VARIOUS POLLENS MAY BE EXPECTED TO BE FOUND IN AIR, BASED ON TIME OF POLLINATING

small blue granules or crystals. This reaction is very distinct and specific for the pollen of these three plants, and it can be used as a mark of identification.

In nitric and in hydrochloric acid the reaction was chiefly one of color, although, as might be expected, swelling took place in a majority of cases. In nitric acid in two cases, *Chenopodium album* and *Liquidambar styraciflua*, an effect upon the pores was visible, the latter standing out in bold relief. Only in a few instances was it possible to conclude from the results obtained the presence of specific chemical compounds.

With alkalis very little difference was observed between the reaction of the pollen grains of different plants. In the tables a color reaction is indicated, not only of the contents but the separate parts of the pollen grains (perine, extine, intine, and pores) sometimes showing different colors.

"Lugol's solution" and iodine water are used in botanical microtechnics as reagents for proteins and as a test solution for starch. Where starch occurs it turns more or less rapidly to dark blue or black. Among the fifty-five kinds of pollen investigated, in thirty-four cases the presence of starch grains could be determined unquestionably. In twenty-one cases the result was negative (see tables). The size of the starch grains varies from very small to large, a distinguishing mark of some value. In some pollens only a very few starch grains can be traced; other pollen grains appear packed with starch. Pollen from dried material in the herbarium failed to show any starch reaction.

The other reagents with which the pollen grains have been tested were the following: ethylic alcohol (95 per cent), acetone, acetic acid, chromic acid, Biuret's and Millon's reagent, vanilline, aniline sulphate, and diphenylamine. In acetic and chromic acid no changes took place, except in one case. It is of interest that in chromic acid (1 per cent) in one case (*Agrostis alba*), a swelling of perine and extine occurred. In the other reagents, except Millon's reagent, no change took place which is worth considering.

In Millon's reagent the pollen grains of *Ambrosia artemisiaefolia, Chenopodium album, Cynodon Dactylon, Dahlia variabilis, Quercus* *alba*, and *Q. coccinea* gave the positive reaction for proteins. This result is significant for the reason that the effect of proteins is considered to be important in the etiology of hay fever. Six plants out of fifty-five is only about 11 per cent; and of these six plants only two are commonly considered to be hay-fever plants of any great importance, *Ambrosia artemisiaefolia* and *Chenopodium album*.

"ACID NIGROSINE" STAIN

While some reagents (acids or alkalis) may bring out the pores for a short time, the reaction is not as definite as it should be, particularly where it is desirable to determine the presence or absence of lids. It has been found necessary for quick identification to make the pores distinct with the aid of a stain. In general the pores do not appear, or they are not easily distinguished in water preparations. Repeated experiments have demonstrated that nigrosine combined with an acetic solution produces the best results, since it immediately makes distinct the acid characters desired and the reaction persists for the necessary length of time. "Acid Nigrosine" is made as follows: To 100 cc. of a 2 per cent acetic acid solution is added 5 cc. of a saturated and filtered alcoholic (ethyl) solution of nigrosine (Gruebler). After mixing thoroughly by shaking, the reagent is ready for use. This reagent has proved to be a very helpful one. By means of this stain there can be distinguished four different classes of openings in the pollen wall.

(1) Pollen grains with large pores which are covered with a lid.
(2) Pollen grains with large pores without a lid (with a very delicate membrane).
(3) Pollen grains with large and very small pores (the large with or without lids).
(4) Pollen grains with a great number of very small pores.

In case 1, the lids of the pores act as a filter. The acid passes through the lids into the contents while the lids hold back the nigrosine and retain it; the lids therefore appear dark violet.

In case 2, where there is no lid (filter), the very delicate membrane allows the stain to pass through unfiltered and to penetrate the contents of the pollen grain. Instead of the contents staining evenly, the stain takes a definite outline from the opening to the center of the pollen grain in the form of a cylinder or cone. When the stain has reached the center of the pollen grain as many cylinder- or cone-shaped stained areas can be distinguished as there were openings in the pollen wall. Later the stain may spread throughout the contents of the grain, but not until the cylinders or cones above referred to can be readily distinguished, and it is always possible to identify the number of openings in the pollen wall by counting the number of cylinder- or cone-shaped regions.

In case 3, the lids of the large pores show the same reaction as in case 1, the stain being retained in the lids. At the same time, however, the stain enters through the small pores and slowly penetrates the contents. The contents beneath the large pores remain unstained, and we are able to count in this way the number of the large pores. If the large pores are not covered with a lid the stain will enter through both the large and small pores, but more rapidly through the large ones because of the larger surface. Since the stain penetrates the contents through the large pores more quickly than through the small ones this makes it possible to determine easily the number of the large pores. Later the contents are stained uniformly.

In case 4, with numerous fine pores, the stain will enter the contents at many places and make its way rapidly and uniformly throughout the interior so that in a short time the whole contents are evenly stained. In some cases a light coloring of the pollen wall may take place but only after the staining of the contents. It is necessary, to obtain the best results, that only small quantities of the stain be applied. Only a small drop should be added to the water preparation and the reaction watched carefully. By using this method and watching the reaction it is easy to determine the kind and number of openings in the wall of the different pollen grains investigated thus far.

The only exception to be noted is that of the pollen of *Pinus austriaca*. The use of "Acid Nigrosine" reagent did not at first seem to demonstrate either pores or lids. After a time, however, the air-sacs began to take the stain, finally assuming a dark violet color. Comparing this result with those obtained with other pollens, it would seem that the tissue of the air-sacs takes the nigrosine in the same way that the lids of the pores in other pollens do. The color is stored in the air-sac tissue while the acid penetrates the contents. It is possible that the tissue of the air-sac should be regarded as nothing but an enlarged lid of a pore which is concealed below the air-sac in the pollen wall. Since pine pollen has two air-sacs we may conclude that most probably the pollen grains of *Pinus austriaca* have two pores covered with lids which have expanded to produce the air-sacs.

Through the coöperation of Dr. H. L. Alexander, of the Washington University School of Medicine, and with the assistance of Mr. L. B. Harrison, a start was made during the summer of 1926 towards a survey of the air in and around St. Louis. By this means, if the work can be continued through several seasons, it is hoped that an accurate knowledge of the prevailing pollens in the air at different times may be obtained.

Various stations were established by Mr. Harrison, and ordinary microscope slides, covered with a film of cotton-seed oil, were exposed for twenty-four hours. These were then brought to the laboratory and examined under the microscope. An attempt was made to use the Cohen dust pump for collecting pollen from the air but the apparatus proved to be too perfect in that it gathered in so much dust with the pollen that the pollen could not be identified. On the whole, no more satisfactory method of getting samples of the pollen in the air than by the exposure of plates covered with some oil or similar adhesive material has been developed.

The observations extended over a period of 115 days (from June 23, 1926, to October 15, 1926). Owing to relative absence of pollen on some days, rain or other disturbing factors, only on 51 days were there positive results. These, with the station from which obtained and the name of the plant, are given below.

Date	Station*	Plant
June 23	1	*Chenopodium ambrosioides*
June 26	2	*Phleum pratense*
June 27	1 3	*Agrostis alba, Dactylis glomerata* *Dactylis glomerata, Plantago lanceolata*
June 28	2 3	*Dactylis glomerata, Agrostis alba* *Dactylis glomerata, Phleum pratense*
June 29	2	*Phleum pratense, Agrostis alba*
June 30	1	*Poa pratensis, Phleum pratense*
July 1	5	*Poa pratensis*
July 2	5 1 2	*Poa pratensis, Agrostis alba* *Poa pratensis, Festuca elatior* *Poa pratensis*
July 3	2 3	*Phleum pratense, Poa pratensis* *Plantago lanceolata, Phleum pratense*
July 4	2 3	*Poa pratensis, Agrostis alba, Phleum pratense* *Phleum pratense*
July 5	1	*Festuca elatior*
July 6	1 2	*Lolium perenne, Rumex acetosella* *Poa pratensis*
July 7	1 3 6	*Phleum pratense* *Phleum pratense* *Rumex acetosella, Agrostis alba*
July 8	2 3 6	*Plantago lanceolata, Rumex acetosella* *Ambrosia artemisiaefolia, Panicum anceps, Festuca elatior* *Phleum pratense, Poa pratensis*
July 11	1	*Phleum pratense, Festuca elatior*
July 12	2	*Chenopodium ambrosioides*
July 14	6	*Festuca elatior, Chenopodium ambrosioides*
July 15	3, 4	*Chenopodium ambrosioides, Festuca elatior*
July 16	2, 4 3	*Festuca elatior* *Chenopodium ambrosioides*
July 19	3 4	*Festuca elatior* *Plantago lanceolata, Phleum pratense*
July 20	1, 2 3 6	*Chenopodium ambrosioides* *Festuca elatior* *Chenopodium ambrosioides, Festuca elatior*
July 23	1 2	*Zea Mays* *Festuca elatior*

Date	Station*	Plant
July 24	4 6	*Phleum pratense* *Phleum pratense*
July 29	1 4	*Chenopodium ambrosioides* *Ambrosia artemisiaefolia*
July 31	1, 2	*Ambrosia artemisiaefolia*
Aug. 1	1	*Ambrosia artemisiaefolia*
Aug. 2	2	*Ambrosia artemisiaefolia*
Aug. 3	6	*Ambrosia artemisiaefolia*
Aug. 4	2 4, 6	*Ambrosia artemisiaefolia* *Ambrosia trifida*
Aug. 5	6	*Ambrosia artemisiaefolia*
Aug. 6	1	*Zea Mays* (?)
Aug. 10	4 6	*Phleum pratense* *Chenopodium ambrosioides, Iva ciliata, Iva xanthifolia*
Aug. 11	1 4	*Chenopodium ambrosioides, Amaranthus retroflexus* *Ambrosia artemisiaefolia*
Aug. 13	3	*Amaranthus retroflexus*
Aug. 14	6	*Ambrosia artemisiaefolia*
Aug. 15	1 2, 3, 4	*Ambrosia artemisiaefolia, Amaranthus retroflexus* *Ambrosia artemisiaefolia*
Aug. 22	2	*Ambrosia artemisiaefolia*
Aug. 24	6	*Chenopodium ambrosioides, Taraxacum officinale*
Aug. 25	1–4, 6	*Ambrosia artemisiaefolia* (great quantities)
Aug. 26	1 2, 6 3 4	*Erigeron canadensis* *Ambrosia artemisiaefolia* *Ambrosia artemisiaefolia, Ambrosia trifida* *Ambrosia artemisiaefolia, Solidago canadensis*
Aug. 28	2, 3	*Ambrosia artemisiaefolia*
Aug. 30	6	*Ambrosia artemisiaefolia*
Sept. 1	1, 3, 4, 6	*Ambrosia artemisiaefolia*
Sept. 7	2, 4 3	*Ambrosia artemisiaefolia* *Ambrosia artemisiaefolia, Chenopodium album*
Sept. 17	1, 2, 3, 4	*Ambrosia artemisiaefolia*
Sept. 18	2 3, 4, 6	*Ambrosia artemisiaefolia, Chenopodium album* *Ambrosia artemisiaefolia*

Date	Station*	Plant
Sept. 20	3 2 6	*Chenopodium album* *Chenopodium album, Ambrosia artemisiaefolia* *Ambrosia artemisiaefolia, Solidago canadensis*
Sept. 21	4	*Ambrosia artemisiaefolia, Chenopodium album, Medicago sativa*
Sept. 30	6	*Ambrosia artemisiaefolia* (great quantities)
Oct. 6	3, 4	*Ambrosia artemisiaefolia*
Oct. 7–15		No pollen grains

* Index of Stations: 1, # 4700 McPherson; 2 and 3, Skinker Road in front of Fine Arts Building of Washington University; 4, Skinker Road at University Street Car Line; 5, south of Forest Park, east of Forest Park Highlands; 6, Medical School of Washington University.

According to the frequency of pollen grains occurring on the slides, the more important plants can be arranged as follows:

Pollen of	Number of days occurred	Per cent
Ambrosia artemisiaefolia	24	49
Phleum pratense	12	24
Chenopodium ambrosioides	10	20
Festuca elatior	9	18
Poa pratensis	7	14
Agrostis alba	6	12
Chenopodium album, Plantago lanceolata	4	8
Amaranthus retroflexus	3	6
Ambrosia trifida, Dactylis glomerata, Rumex acetosella, Solidago canadensis, Zea Mays	2	4
Erigeron canadensis, Iva ciliata, Iva xanthifolia, Lolium perenne, Medicago sativa, Panicum anceps, Taraxacum officinale	1	2

DESCRIPTION OF POLLENS

Acer Negundo (*Box Elder*). *No. 50.*[1]—Pollinating from middle of March until middle of April. Tetrahedral, 3 pores without lids; 25–40 μ. Contents granular. The dry pollen taken directly from the anthers is folded and shaped like a grain of rye; in water preparation the pollen grains stretch and become tetrahedral. Color grayish yellow. In "Acid Nigrosine" the contents below the pores stain dark violet. Starch present.

Acer platanoides (*Norway Maple*). *No. 43.*—Pollinating from middle of April until middle of May. Tetrahedral, 3 pores with

[1] Numbers refer to those used in key.

lids; 30 × 38 μ. Contents coarse-grained. The pollen wall very thick and shows distinct layers. Color yellowish gray. "Acid Nigrosine" stains the lids of the pores dark violet. No starch present.

Agrostis alba (*White Bent Grass*). *No. 28.*—Pollinating May and June. Elliptical, 1 pore with a lid; 17 × 24–25 × 32 μ. Contents finely granulated. Pollen wall thick. Extine with very delicate light red-brown shimmer. In water grains appear bean-shaped. Colorless. "Acid Nigrosine" stains first the lids of the pores and later the contents. In chromic acid the wall swells and appears very thick (3.5 μ). Starch present.

Ailanthus glandulosa (*Tree of Heaven*). *No. 45.*—Pollinating middle of May until end of June. Tetrahedral, in water more or less spherical, 3 large pores with lids and numerous fine pores; 20–50 μ. Contents finely granular. Color yellow. "Acid Nigrosine" stains the lids of the pores dark violet. Starch may or may not be present. In ammonia water the fine pores become very distinct.

Amaranthus retroflexus (*Pigweed*). *No. 11.*—Pollinating end of July until middle of August. Spherical, numerous fine pores with lids in the thick wall; 23–25 μ. Color grayish yellow. "Acid Nigrosine" stains the pores dark blue and later the contents become violet. Starch present.

Ambrosia artemisiaefolia (*Common or Lesser Ragweed*). *No. 18.*—Pollinating beginning of August until middle of October. Spherical, 3 pores with lids. Pores placed equatorially. Surface studded with obtuse spines; 17–22 μ. Dry grains appear compressed and therefore elliptical, but in water they stretch and become spherical. Color yellow. "Acid Nigrosine" stains only the lids of the pores dark violet. No starch present. Contents give very weak protein reaction in both Millon's and Biuret's reagent.

Ambrosia trifida (*Great Ragweed*). *No. 27.*—Pollinating August and September. Spherical, 3 pores without lids. Pores placed equatorially. Surface studded with short obtuse spines; 35–42 μ. Color golden. "Acid Nigrosine" stains the pores dark violet. Starch present.

Anthoxanthum odoratum (*Sweet Vernal Grass*). *No. 29.*—Pollinating first half of May. Elliptical, almost spherical, 1 pore with lid; 32 × 25–34 × 37 μ. Contents coarse-grained. Color yellowish. "Acid Nigrosine" stains the lid of the pore dark violet. Starch present.

Artemisia absinthium (*Wormwood*). *No. 12.*—Pollinating June until the end of August. Spherical, 3 pores with lids. Spiculated surface with oil drops; 20–28 μ. The dry grains appear elliptical. Color yellow. "Acid Nigrosine" stains the lids of the pores dark violet. No starch present. Sulphuric acid produces in the dissolved contents blue granules and crystals (lipochromes?).

Aster novae Angliae (*New England Aster*). *No. 13.*—Pollinating August until October. Spherical, in water somewhat flat, 3 pores with lids; 24–28 μ; young grains 17–22 μ. The surface is studded with short warty spines, 1.7–3.5 μ in length, covered with numerous oil drops. Color yellow. In "Acid Nigrosine" the lids of the pores swell and stain dark violet. In mature grains the extine separates from the pores and they stand out in bold relief. No starch present. In sulphuric acid the dissolved contents and the oil drops appear blue (lipochromes).

Betula populifolia (*American White Birch*). *No. 7.*—Pollinating end of February to the middle of March. Spherical, 3 pores with lids; 27–32 μ. Color yellow. "Acid Nigrosine" stains the lids of the pores dark violet. Abundant starch present.

Carya alba (*Shagbark Hickory*). *No. 34.*—Pollinating last half of May. Elliptical, 3 pores (sometimes 4) with lids; 38 × 49–63 × 70 μ. Pollen wall thick (3.5 μ). Light grayish yellow. "Acid Nigrosine" stains lids of the pores dark violet. In acetic acid the pollen grains become spherical and show fine granulated contents with large oil drops. Starch present.

Chenopodium album (*Lamb's Quarters*). *No. 26.*—Pollinating July until the end of September. Spherical, numerous small pores without lids; 20–32 μ. Surface smooth, contents coarse-granular. Color dirty yellow. "Acid Nigrosine" stains first the pores dark violet, later the contents. Starch present. Millon's reagent gives a positive result.

Chenopodium ambrosioides (*Wormseed*). *No. 55.*—Pollinating end of August until end of October. Polyhedral, numerous fine pores; 24–28 μ. Surface appears uneven, contents coarse-granular. Color yellowish gray. "Acid Nigrosine" rapidly stains the contents violet. In acetic acid the pores become distinctly visible. Starch present.

Chrysanthemum leucanthemum (*Ox-eye Daisy*). *No. 47.*—Pollinating July until the middle of August. Tetrahedral, 3 pores with lids; 23–28 μ. Surface studded with spines, contents granulated. "Acid Nigrosine" stains lids of pores dark violet. Color yellowish gray. No starch present.

Corylus americana (*American Hazelnut*). *No. 44.*—Pollinating end of February and first half of March. Tetrahedral, 3 pores with lids; 28–35 μ. Surface smooth, contents granulated. Color yellow. "Acid Nigrosine" stains lids of pores dark violet. Methylene blue stains first the pores dark blue, then the contents. Starch present.

Cynodon Dactylon (*Bermuda Grass*). *No. 1.*—Pollinating June until middle of September. Spherical, 1 pore with a lid; 30–38 μ. Contents granulated, surface smooth. "Acid Nigrosine" stains the lid of the pore dark violet. Color dirty yellow. Starch present. Millon's reagent gives a positive result.

Dactylis glomerata (*Orchard Grass*). *No. 30.*—Pollinating end of May and during June. Elliptical, 1 pore with a lid; 24 × 28–32 × 39 μ. Surface smooth, contents coarse-granular. Color grayish. "Acid Nigrosine" stains first the lids of the pores and then the perine. Abundant starch present.

Dahlia variabilis (*Common Dahlia*). *No. 21.*—Pollinating September until October (first frost). Spherical, 12 to 20 large pores with lids; 28–35 μ. Surface covered with oil drops and studded with sharp-pointed spines 3.5 μ in length. Color yellow. "Acid Nigrosine" stains the lids of the pores dark violet. Starch present. Sodium hydroxide changes the color of the contents from bright red to orange, then light brown and finally to yellow (typical tyrosine reaction). The perine swells. Millon's reagent gives a positive result.

Erigeron canadensis (*Horseweed*). *No. 15.*—Pollinating August and September. Spherical, 3 pores with lids; 16–22 μ. Surface spiny. Color pale yellowish gray. "Acid Nigrosine" slowly stains the lids of the pores violet, gradually becoming darker; later the entire contents become dark violet. No starch present.

Festuca elatior (*Meadow Fescue*). *No. 2.*—Pollinating June and July. Spherical, 1 pore with a lid; 23–30 μ. Colorless. "Acid Nigrosine" stains the lid of the pore dark violet, later the contents light violet. Starch present.

Fraxinus americana (*White Ash*). *No. 38.*—Pollinating second and third week in April. Elliptical, 3, sometimes 4, pores without lids, the pores arranged in a circle around the longer axis; 21 × 24–24 × 32 μ. Surface smooth, contents granular. Color brown. "Acid Nigrosine" stains the contents beneath the pores dark violet. Starch present.

Gleditschia triacanthos (*Honey Locust*). *No. 35.*—Pollinating from the middle until the end of May. Elliptical, almost spherical, 3 pores with lids; 28 × 32–42 × 46 μ. Surface finely granular with oil drops in places. Color light greenish yellow. In "Acid Nigrosine" the lids of the pores swell and stain dark violet. No starch present.

Helianthus annuus (*Common Sunflower*). *No. 14.*—Pollinating July until end of September. Spherical, 3 pores with lids; 30–40 μ. Surface covered with oil drops and studded with sharp-pointed spines, 3.5–7 μ in length. Color dirty yellow. In "Acid Nigrosine" lids of pores swell and stain dark violet. In sulphuric acid the oil drops turn blue (lipochromes?). No starch present.

Iva ciliata (*Rough Marsh Elder*). *No. 17.*—Pollinating August until middle of October. Spherical, 3 pores with lids; 24–28 μ. Surface spiny, wall very thick. Color grayish yellow. "Acid Nigrosine" stains dark violet, first, the lids of the pores, later, the contents. Very few starch grains.

Iva xanthifolia (*Burweed Marsh Elder*). *No. 41.*—Pollinating July until September. Elliptical, 3 pores without lids; 14 × 17–17 × 21 μ. Surface studded with spines. Color grayish yellow. With "Acid Nigrosine" the stain enters the pores and penetrates the contents to the center, forming dark violet-colored cones. Starch present.

Ligustrum vulgare (*Privet*). *No. 54.*—Pollinating May until July. Spherical, 3 (sometimes 4) pores without lids; 24–35 μ. Surface reticulated. Color yellow. Contents granulated. "Acid Nigrosine" stains the contents below the pores dark violet. No starch could be recognized.

Liquidambar styraciflua (*Sweet Gum*). *No. 10.*—Pollinating second half of April. Spherical, 12–20 large pores with lids and numerous fine pores; 35–42 μ. Surface smooth, wall very thick (1.7–3.5 μ). Color yellowish. "Acid Nigrosine" stains the lids of the large pores, and since the stain enters through the small pores, the contents in a short time appear dark violet. If only small quantities of the stain are used the larger pores can easily be detected. In chloral hydrate the structure of the grains becomes distinct, especially the pores and the layers of the wall, and the grains assume a polyhedral shape. Starch present.

Lolium perenne (*Darnel or Rye Grass*). *No. 31.*—Pollinating last week of May until end of June. Elliptical, 1 pore with a lid; 24 × 31–32 × 39 μ. Surface smooth, wall very thick (2.5–3 μ). Color yellowish. Contents granular. Lid of the pore stains dark violet in "Acid Nigrosine." No starch present.

Medicago sativa (*Alfalfa*). *No. 36.*—Pollinating May until October. Elliptical, 3 pores with lids; 31 × 35–42 × 45 μ. Surface reticulated. Color grayish yellow. Contents granular. "Acid Nigrosine" quickly stains the lids of the pores dark violet. No starch present.

Melilotus alba (*Sweet clover*). *No. 48.*—Pollinating May until October. Tetrahedral, 3 pores with lids; 20–28 μ. Surface with cone-shaped projections from the pores. Color greenish yellow. Contents granular. "Acid Nigrosine" stains the lids of the pores at first, later the projections. No starch present.

Morus alba (*White Mulberry*). *No. 6.*—Pollinating second half of April. Spherical, 2 pores with lids; 17–21 μ. Surface smooth. Contents granular. Color light gray-brown. "Acid Nigrosine" acts slowly, staining first the lids of the pores and later the pollen wall. Starch present.

Panicum anceps (*Beaked Panicum*). *No. 3.*—Pollinating early July until September. Spherical, 1 pore with lid (dry pollen grains appear elliptical). The pore stands out in bold relief; 30–38 μ; Surface smooth. Contents granular. Color light yellowish gray. "Acid Nigrosine" stains the lid dark violet. Starch present.

Phleum pratense (*Timothy*). *No. 32.*—Pollinating June until end of August. Elliptical, 1 pore with lid; 25 × 31–33 × 35 μ.

Surface smooth. Contents granular. Color light yellow. "Acid Nigrosine" quickly stains the lids of the pores; later the contents are faintly colored. Starch present.

Pinus austriaca (*Austrian Pine*). *No. 40.*—Pollinating first half of May. Elliptical (swelling in water until almost spherical), with 2 air-sacs and probably with 2 pores; 31 × 50–50 × 70 μ; without air-sacs, 31 × 40–38 × 55 μ. No surface markings except air-sacs. Color light yellow with air-sacs black. "Acid Nigrosine" slowly stains the air-sacs violet. In sulphuric acid the air-sacs show a very fine reticular structure. In acetic acid the grains swell and the wall appears very thick (5.2 μ); the pollen grains become bean-shaped. Contents granular. Starch present.

Plantago lanceolata (*English Plantain or Rib Grass*). *No. 9.*—Pollinating middle of May until end of September. Spherical, 12 pores with lids; 20–28 μ. Surface smooth. Contents coarsely granular. Color yellowish gray. "Acid Nigrosine" stains lids of pores dark violet. Starch present.

Plantago major (*Common Plantain*). *No. 8.*—Pollinating June until end of September. Spherical, 6 pores with lids; 20–25 μ. Surface smooth, wall thick. Contents coarsely granular. Color very pale yellow, almost colorless. "Acid Nigrosine" stains at first the lids of the pores and later the contents. Starch present.

Platanus occidentalis (*Sycamore or Buttonwood*). *No. 51.*—Pollinating in May. Tetrahedral, 3 pores without lids; 20–34 μ. Surface smooth. Contents coarsely granular. Color weak dirty yellow. "Acid Nigrosine" stains at first beneath the pores, later all the contents. Starch grains very small and not in great quantity.

Poa pratensis (*Blue Grass*). *No. 4.*—Pollinating from middle of May until end of September. Spherical, 1 pore with a lid; 31–37 μ. Surface smooth. Contents coarsely granular. Color greenish yellow. In "Acid Nigrosine" the lids of the pores first stain dark violet, whereas the pores themselves appear greenish blue. Later the contents take the color and stain dark violet. No starch present.

Polygonum persicaria (*Knotweed or Lady's Thumb*). *No. 23.*—

Pollinating August and September. Spherical, numerous large pores (more than 20) with lids; 28–53 μ. Surface reticulated. Contents granular. Color very light yellow. "Acid Nigrosine" stains the lids of the pores dark violet. In sulphuric, nitric, and hydrochloric acid the folded structure of the reticulations becomes very distinct. Starch present.

Populus balsamifera (*Balsam Poplar*). *No. 25.*—Pollinating middle of March. Spherical, numerous small pores; 20–40 μ. Surface fine-granular. Contents coarse-granular. Color yellow. "Acid Nigrosine" stains the contents dark violet, the wall light violet. The intine and likewise the contents give a positive reaction for myriophylline; in vanilline-hydrochloric acid, pinkish and purple; in diphenylamine from yellow to pink to brown. Raciborski ('93) has determined myriophylline in the young leaves of *Myriophyllum* (hence the origin of the name). Starch present.

Pyrus Malus (*Common Apple*). *No. 52.*—Pollinating in May. Tetrahedral, 3 pores without lids; 34–35 μ. Surface marked with cone-shaped projections from the pores. Contents coarse-granular. Color pale yellowish gray. "Acid Nigrosine" stains the contents dark violet immediately beneath the pores; later the stain moves toward the center in cone-shaped areas. No starch present.

Quercus alba (*White Oak*). *No. 19.*—Pollinating in May. Spherical, 3 pores with lids which are elongated in cone-shaped projections; 28–34 μ. Contents coarse-granular, containing, in addition to a few small starch grains, globoids with protein crystals. Wall thick. Color yellowish. "Acid Nigrosine" stains the lids of the pores and the projections from the lids dark violet. In potassium hydroxide the globoids become distinct. The contents give a positive protein reaction in Millon's reagent. Starch present.

Quercus coccinea (*Scarlet Oak.*) *No. 49.*—Pollinating in May. Tetrahedral, 3 pores with lids and cone-shaped projections from the pores; 24–35 μ. Surface smooth, wall thick. Contents coarse-granular. In "Acid Nigrosine," at first the lids of the pores stain dark violet, then the projections light violet; later the places beneath the pores take the color. The contents give the positive protein reaction in Millon's reagent. No starch present.

Quercus rubra (*Red Oak*). *No. 42.*—Pollinating in May. Tetrahedral, 3 pores with lids; 24–35 μ. Surface smooth. Contents coarse-granular. Color dirty yellow. "Acid Nigrosine" stains the lids of the pores dark violet, later penetrating beneath the pores. No starch present.

Robinia pseudacacia (*Common Locust*). *No. 46.*—Pollinating at end of April and early in May. Tetrahedral, 3 pores with lids; 28–41 μ. Surface finely granulated. Color light grayish yellow. "Acid Nigrosine" stains the lids of the pores dark violet. Starch present in very small grains.

Rudbeckia laciniata (*Tall Cone-flower*). *No. 16.*—Pollinating in August and September. Spherical, 3 pores with lids; 20–25 μ. Surface studded with spines about 3.5 μ in length. Color yellow. "Acid Nigrosine" stains the lids of the pores dark violet. No starch present.

Rumex acetosella (*Sheep Sorrel*). *No. 39.*—Pollinating from May until August. Elliptical, 4 pores without lids; 21 × 24–24 × 28 μ. Surface smooth with occasional oil drops. Contents coarsely granular. Color yellow. "Acid Nigrosine" very slowly stains the pores pale violet.

Solidago canadensis (*Canada Golden-rod*). *No. 37.*—Pollinating from August until first half of October. Elliptical, 3 pores with lids; 15 × 21–18 × 24 μ. Surface studded with obtuse spines and covered with oil drops. The spines are arranged in rows parallel to the longer axis. "Acid Nigrosine" stains the lids of the pores dark violet. No starch present.

Taraxacum officinale (*Dandelion*). *No. 22.*—Pollinating all the year. Spherical, 12–20 pores with lids; 35–50 μ. Surface reticulated and studded with short blunt spines. Oil drops also abundantly present. Color gold. "Acid Nigrosine" very slowly stains the pores. Sulphuric acid turns the oil drops blue (lipochromes?). No starch present.

Trifolium pratense (*Red Clover*). *No. 20.*—Pollinating from April until November. Spherical, 3 pores with lids and cone-shaped projections from the pores; 28–41 μ. Surface smooth. Color grayish. "Acid Nigrosine" stains the pores and the lids dark violet, the projections light violet. No starch present.

Typha latifolia (*Common Cat-tail*). *No. 5.*—Pollinating in June. Single pollen grains spherical, 1 pore with a lid with margin, pollen wall penetrated by very fine pores; 24–35 μ; groups from 2–5 pollen grains 35 × 42–49 μ, and 38 × 42–45 μ. Single pollen grains occur rarely; usually they are united in irregular aggregations from 2–5 grains. Surface smooth. Color yellow. "Acid Nigrosine" stains only the lids of the pores dark violet. In sulphuric acid the structure of the extine becomes very distinct and the numerous fine pores can be identified very easily. In contradistinction to *Typha latifolia, Typha angustifolia* has only single pollen grains which never occur in aggregations. Size 30–42 μ. Each pollen grain has 1 pore with lid, and numerous fine pores, but the surface is granulated. Starch present.

Ulmus americana (*American Elm*). *No. 53.*—Pollinating middle of March until middle of April. Polyhedral, 5 pores with lids; 25–35 μ. Surface smooth. Contents finely granular. Color grayish yellow. "Acid Nigrosine" stains only the lids of the pores dark violet. No starch present.

Xanthium spinosum (*Burweed or Cocklebur*). *No. 24.*— Pollinating from second week of August until second half of September. Spherical, 3 large pores without lids and numerous fine pores; 22–28 μ. Surface smooth. Contents coarse-granular. Color light brown. In "Acid Nigrosine" the pores and places beneath the pores stain dark violet; the contents stain later. No starch present.

Zea Mays (*Indian Corn*). *No. 33.*—Pollinating latter part of June and first half of July. Elliptical, 1 assymetrically placed pore with a lid; 70 × 75–85 × 88 μ. The differences in length of the axis are not very great but spherical pollen grains occur rarely. Surface smooth. Contents granular. Color light yellow. "Acid Nigrosine" stains first the lids of the pores dark violet, later the pollen wall. Starch present.

Key

The key is based primarily on the shape of the pollen and number of pores. As subdivisions the presence or absence of lids on the pores and surface markings have been used because they are characteristics and stable. The presence of different projections, such as spines, warts, etc., is very helpful in identification. For some of the spherical pollen grains it was necessary to take into account the presence or absence of starch as well as the comparative size of the grains. Starch, which can be determined easily, is perhaps the only chemical distinction which is of use. Attention should also be paid to the time of pollination which is of great assistance in some cases.

It may be a disputed point whether the tetrahedral and polyhedral pollen should not be regarded as spherical. While these are actually spherical, departure from this shape is caused by the pores, which by their position produce a three- or many-sided appearance. However, since under practically all conditions the angular shape remains constant and there is no difficulty in recognizing it under the microscope, it seems one of the most readily determined characters for identification.

Key

I. *Spherical pollen grains, large pores with lids*			
1. Without surface markings			
A. *1 pore*			
a. Single pollen grains			
α. With starch grains 0.5–1.7 μ			
Starch grains 0.5–0.6 μ; pollen grains 30–38 μ.	June–Sept.	*Cynodon Dactylon*	1
Starch grains 0.8–1.1 μ; pollen grains 23–30 μ	June, July	*Festuca elatior*	2
Starch grains 1.1–1.7 μ; pollen grains 30–38 μ	July–Sept.	*Panicum anceps*	3
β. Without starch grains			
Coarse-grained; pollen grains 31–37 μ	May–Sept.	*Poa pratensis*	4
b. Pollen grains aggregated in groups from 2–5, 35 × 42–35 × 49 μ; single pollen grains 24–35 μ	June	*Typha latifolia**	5
B. *2 pores*			
17–21 μ	April	*Morus alba*	6
C. *3 pores*			
27–32 μ	Feb., Mar.	*Betula populifolia*	7
D. *6 pores*			
20–25 μ	June–Sept.	*Plantago major*	8
E. *12 pores*			
20–28 μ	May–Oct.	*Plantago lanceolata*	9
F. *12–20 pores*			
35–42 μ	April	*Liquidambar styraciflua*	10
G. *More than 20 pores*			
23–25 μ	July., Aug.	*Amaranthus retroflexus*	11
2. With surface markings			
A. *3 pores*			
a. Surface spiny			
α. Oil drops on surface			
Spines 1.7–3.5 μ; pollen grains 20–28 μ	June–Aug.	*Artemisia absinthium*	12
Spines 1.7–3.5 μ; pollen grains 24–28 μ	Aug.–Oct.	*Aster novae Angliae*	13
Spines 3.5–7 μ; pollen grains 30–40 μ	July–Sept.	*Helianthus annuus*	14
β. No oil drops on surface			
Spines 0.8–0.9 μ; pollen grains 16–22 μ	Aug., Sept.	*Erigeron canadensis*	15
Spines 3.5 μ; pollen grains 20–25 μ	Aug., Sept.	*Rudbeckia laciniata*	16

b. Surface warty			
Warts 1.2 μ; pollen grains 24–28 μ	Aug.–Oct.	*Iva ciliata*	17
Warts 1.7 μ; pollen grains 17–22 μ	Aug.–Oct.	*Ambrosia artemisiaefolia*	18
c. Surface with cone-shaped projections from pores			
Starch present; pollen grains 28–34 μ	May	*Quercus alba*	19
Starch absent; pollen grains 28–41 μ	Apr.–Nov.	*Trifolium pratense*	20
B. *12–20 pores*			
a. Surface with oil drops and sharp spines; pollen grains 28–35 μ	Sept., Oct.	*Dahlia variabilis*	21
b. Surface with oil drops and short blunt spines; pollen grains 35–50 μ	All the year	*Taraxacum officinale*	22
C. *Numerous pores*			
a. Surface with hexagonal reticulations; pollen grains 28–53 μ	Aug., Sept.	*Polygonum persicaria*	23
II. *Spherical pollen grains, large pores without lids*			
1. Without a surface marking; with numerous fine pores			
A. *3 large pores;* contents coarse; pollen grains 22–28 μ	Aug., Sept.	*Xanthium spinosum*	24
B. *No large pores*			
Pollinating in March; pollen grains 20–40 μ	March	*Populus balsamifera*	25
Pollinating July–September; pollen grains 20–32 μ	July-Sept.	*Chenopodium album*	26
2. With surface markings			
A. 3 pores; surface spiculated; pollen grains 35–42 μ	Aug., Sept.	*Ambrosia trifida*	27
III. *Elliptical pollen grains, large pores with lids*			
1. Without surface markings			
A. *1 pore*			
a. Pore placed laterally; very small starch grains; pollen grains 17 × 24–25 × 32 μ	May, June	*Agrostis alba*	28
b. Pore placed at one end of the longer axis; pollen grains 32 × 35–34 × 37 μ; small starch grains	May	*Anthoxanthum odoratum*	29
c. Pore placed at one end of the longer axis; numerous fine pores in the pollen wall; large starch grains; pollen grains 24 × 28–32 × 39 μ	May, June	*Dactylis glomerata*	30
d. Pore placed at one end of the longer axis; no starch grains; pollen grains 24 × 31–32 × 39 μ	May, June	*Lolium perenne*	31
e. Pore placed laterally; large starch grains; pollen grains 25 × 31–33 × 35 μ	June–Aug.	*Phleum pratense*	32
f. Pore placed laterally; large starch grains; pollen grains 70 × 75–85 × 88 μ	June, July	*Zea Mays*	33
B. *3 pores*			
Starch grains; pollen grains 38 × 49–63 × 70 μ	May	*Carya alba*	34
No starch grains; pollen grains 28 × 32–42 × 46 μ	May	*Gleditschia triacanthos*	35
2. With surface markings			
A. *3 pores*			
Small reticulations; pollen grains 31 × 35–42 × 45 μ	May–Oct.	*Medicago sativa*	36
Obtuse spines; pollen grains 15 × 21–18 × 24 μ	Aug.–Oct.	*Solidago canadensis*	37
IV. *Elliptical pollen grains, large pores without lids*			
1. Without surface markings			
A. *3–4 pores;* pollen grains 21 × 24–24 × 31 μ	April	*Fraxinus americana*	38
B. *4 pores;* pollen grains 21 × 24–24 × 28 μ	May–Aug.	*Rumex acetosella*	39
2. With surface markings			
A. *2 pores; 2 air-sacs;* pollen grains 31 × 50–50 × 70 μ (31 × 40–38 × 55 μ)	May	*Pinus austriaca*	40
B. *3 pores; surface spiny;* pollen grains 14 × 17–17 × 21 μ	July–Sept.	*Iva xanthifolia*	41

V. *Tetrahedral pollen grains*			
A. *3 pores with lids*			
1. Surface smooth			
a. Pollinating in May; contents coarse-grained; pollen grains 24–35 μ	May	*Quercus rubra*	42
b. Pollinating in April; contents coarse-grained; pollen grains 30–38 μ	April, May	*Acer platanoides*	43
c. Pollinating in February and March; contents fine-granulated; pollen grains 28–35 μ	Feb., Mar.	*Corylus americana*	44
d. Pollinating in May and June; contents fine-granulated; pollen grains 20–50 μ	May, June	*Ailanthus glandulosa*	45
2. Surface with markings			
a. Surface fine-granulated; pollen grains 28–41 μ	April, May	*Robinia pseudacacia*	46
b. Surface spiny; pollen grains 23–28 μ	July, Aug.	*Chrysanthemum leucanthemum*	47
c. Surface with cone-shaped projections from pores			
α. Contents fine-granular, starch present; pollen grains 20–28 μ	May–Oct.	*Melilotus alba*	48
β. Contents coarse-grained; no starch present; pollen grains 24–35 μ	May	*Quercus coccinea*	49
B. *3 pores without lids*			
a. Surface smooth			
α. Contents granular; pollen grains 25–40 μ	Mar., Apr.	*Acer Negundo*	50
β. Contents coarse; pollen grains 20–34 μ	May	*Platanus occidentalis*	51
b. Surface with cone-shaped projections from pores; contents coarse; pollen grains 34–35 μ	May	*Pyrus Malus*	52
VI. Polyhedral pollen grains			
1. *With lids*			
A. 5 pores; pollen grains 25–35 μ	Mar., Apr.	*Ulmus americana*	53
2. *Without lids*			
A. 3 large pores; pollen grains 24–35 μ	May–July	*Ligustrum vulgare*	54
B. Numerous fine pores; pollen grains 24–28 μ	Aug.–Oct.	*Chenopodium ambrosioides*	55

* The pollen of *Typha latifolia* is easily distinguished from that of *Typha angustifolia*, the latter having grains always spherical and occurring singly, never in aggregations. Measurements: 30–42 μ. The surface is fine-granulated and the pollen wall is penetrated by numerous fine pores. Each pollen grain has one large pore with a lid.

Synoptical Table

As a complement to the key, the following synoptical table has been prepared. The table may be of some assistance to those wishing to have a summary of the various characters of a particular pollen. Only the more important reactions have been noted, it being superfluous to mention reactions which occur universally and are very well known to every investigator.

Plant	*Acer Negundo*	*Acer platanoides*	*Agrostis alba*	*Ailanthus glandulosa*
Pollinating	Mar. 23–Apr. 4	Apr.–May	May–June	End May–end June
Size	25–40 μ	30–38 μ	17 × 24–25 × 32 μ	20–50 μ
Shape and marks*	t O^1; S smooth; C granular	t O^3 L; S smooth; C coarse	e O^1 L; S smooth; C fine-granulated	t O^3 L o^n; S smooth; C granular
Color	Grayish yellow	Yellowish gray	Colorless	Light yellow
Sulphuric acid	Grayish yellow–golden–brown	Lemon–pale lemon	E pink–purple; P golden–light yellowish; O distinct	Orange–brown; fine pores distinct
Nitric acid	Grayish lemon–yellowish; C swell	No change	PE swell a little, show Str red-brown–delicate purple	Lemon–yellow–greenish yellow; C swell and creep out
Hydrochloric acid	Grayish yellow–lemon–dirty yellow	C swell to double size; PW yellowish; Str distinct	C yellow–colorless; PE golden–delicate greenish yellow	Lemon–dirty yellow; C swell and creep out
Iodine water	Light brown; St black	Dark brown; no starch	Brown; St black	Brown; St black; P yellow
"Lugol's solution"	Brown; St black	Dark brown; no starch	Brown; C and L darker than PW; St black	Brown; St black; P yellow
Ammonia water	No reaction	C swell a little and clear up; granules in the C disappear	Yellow–colorless; C and O^1 Str distinct; P purple	Light yellow; C transparent; Str distinct
Sodium hydroxide	Yellowish, transparent; C swell	C lemon–pale lemon; Str of PW very distinct	Yellow–colorless; P and I yellow; E bright red-brown, distinct	Golden; I red-brown, distinct
Potassium hydroxide	Yellowish, transparent; C swell	C swell threefold, creep out; PW lemon	Same as above	Greenish yellow–yellow–golden; I light red-brown
"Acid Nigrosine"	Parts below the O dark violet	L stain dark violet	L dark violet; later C violet, P light violet	L dark violet

* *Abbreviations used in the Synoptical Table:*
Shape.—e, elliptical; p, polyhedral; s, spherical; t, tetrahedral.
Pores.—O, large pores; o, small pores; L, lid of a pore.
The number of the pores is expressed by an index figure, thus—O^3L, three large pores with lids; O^1, one large pore without a lid; O^n, numerous large pores; o^n, numerous small pores.
Other abbreviations.—C, contents; E, extine; I, intine; P, perine; PW, pollen wall; S, surface; St, starch; Str, structure.

Plant	*Amaranthus retroflexus*	*Ambrosia artemisiaefolia*	*Ambrosia trifida*	*Anthoxanthum odoratum*
Pollinating	End July–first half Aug.	Aug.–Oct.	Aug.–Sept.	May
Size	23–25 μ	17–22 μ	35–42 μ	32 × 35–34 × 37 μ
Shape and marks	s o^n L; S smooth; C coarse	s O^3 L; S obtuse spines equatorially arranged	s O^3; S spiculated	e O^1 L; S smooth; C coarse
Color	Grayish yellow	Yellow	Golden	Yellowish
Sulphuric acid	Lemon–orange–light brown–purple; o distinct	Lemon–light yellow–colorless	Yellow–colorless; PE swell, layers distinct; P at last greenish yellow	Lemon–yellow–light brown; grains swell a little
Nitric acid	Lemon; I very delicate purple	Greenish yellow–light yellow; C swell and creep out	Colorless; P light yellowish; C swell and creep out	Colorless; C swell a little; I lavender and purple; P distinct
Hydrochloric acid	P red-brown–purple	Lemon–golden; C swell	Lemon–deep yellow; C swell and creep out	Yellowish–colorless; PW lemon–bright orange; OL distinct
Iodine water	Light brown; St black	Greenish yellow–brown; no starch	Brown; St black	Light brown; St black; PW dark brown
"Lugol's solution"	Brown; St black; P colorless	Light brown; no starch	Light brown; St black	As in iodine water
Ammonia water	Light brown	Yellowish green; C swell and creep out	Lemon; C shrink	PW lavender
Sodium hydroxide	Light brown; I red-brown	Golden–greenish yellow; C swell and creep out	Greenish yellow–light yellow; C swell and creep out	PW bright orange very distinct
Potassium hydroxide	Light brown; I red-brown	Golden–greenish yellow	Lemon; C swell and creep out	As in sodium hydroxide
"Acid Nigrosine"	o dark violet; C later violet	L dark violet	O dark violet	L stains dark violet

Plant	*Artemisia absinthium*	*Aster novae Angliae*	*Betula populifolia*	*Carya alba*
Pollinating	June–Aug.	Aug.–Oct.	Feb.–Mar.	May
Size	20–28 μ	24–28 μ	27–32 μ	38 × 49–63 × 70 μ
Shape and marks	s O^3 L; S spiny	s O^3 L; S spiny; oil drops	s O^3 L	e O^3 L; S smooth; C coarse
Color	Yellow	Yellow	Yellow	Light grayish yellow
Sulphuric acid	Dirty yellow–grayish blue; PW dirty green, finally light green; C blue granules and crystals	Green–greenish yellow–blue; oil drops blue	Lemon–orange–golden–brown	Orange–lemon–light yellow
Nitric acid	Light yellow–colorless	Almost colorless; C swell and creep out, forming drops on the pores	Lemon–greenish yellow; C swell; P and O distinct	Lemon–light yellow; P lemon; E very delicate pinkish; C swell and creep out
Hydrochloric acid	Entirely decolorized	C swell and creep out; oil drops deep golden	Yellowish green; C swell and creep out	Golden–light yellow; P light brown

Plant	*Artemisia absinthium*	*Aster novae Angliae*	*Betula populifolia*	*Carya alba*
Iodine water	Light brown; L yellow; no starch	Light brown; no starch; oil drops greenish	Black (stuffed with starch); P brown; O yellow	Golden-brown; St black
"Lugol's solution"	Brown; L yellow; no starch	Brown; no starch; oil drops greenish	C black (starch); O light brown	Brown; St black; P golden
Ammonia water	Lemon-light yellow-dirty yellow; C swell	Greenish yellow; C swell a little	Greenish yellow	Yellow; P darker, swells to double size
Sodium hydroxide	Lemon-golden-colorless	Pale yellow-light yellow	Golden; Str distinct	Yellow; P golden; O and layers distinct
Potassium hydroxide	As in sodium hydroxide; oil drops golden	Greenish yellow-light yellow; C swell, become distinct	Yellow; Str distinct	As in sodium hydroxide
"Acid Nigrosine"	L stain dark violet	L stain dark violet	L stain dark violet	L stain dark violet

Plant	*Chenopodium album*	*Chenopodium ambrosioides*	*Chrysanthemum leucanthemum*	*Corylus americana*
Pollinating	July-Sept.	Aug.-Oct.	July-Aug.	Feb.-Mar.
Size	20-32 μ	24-28 μ	23-28 μ	28-35 μ
Shape and marks	s o^n; S smooth; C coarse	p o^n; S smooth; C coarse	t O^3 L; S spiny; C granulated	t O^3 L; S smooth; C granulated
Color	Dirty yellow	Light yellowish gray	Yellowish gray	Yellow
Sulphuric acid	Orange-bright red-brown; C pale yellow; PW bright red-brown	Orange-red-brown-ruby-colored-purple	Lemon-greenish yellow-dirty yellow-colorless	Grayish yellow-orange-light brown
Nitric acid	Bright yellow-pale yellow; C swell a little and creep out	Lemon; o distinct	Colorless	No change
Hydrochloric acid	Yellow	C yellow; I red-brown	Golden-grayish yellow-colorless; S golden oil drops	Yellowish-greenish; C swell and creep out
Iodine water	Brown; St black	Light brown; St black	C yellow; PW brown; no starch	Brown; St black; P light brown
"Lugol's solution"	Dark brown; St black	Light brown; St black	C dark yellow; PW brown; no starch	Golden brown; St black; O golden
Ammonia water	Lemon-yellow-light yellow	Grains shrink; I bright red-brown	Yellow-golden-lemon; C swell and creep out	Golden-yellow
Sodium hydroxide	Golden-light brown (bright)	Lemon-light brown; o distinct	Lemon; C swell and creep out	Lemon-yellow
Potassium hydroxide	Golden-lemon-yellow	Lemon; P bright red-brown; grains swell; o distinct	As in sodium hydroxide	As in sodium hydroxide
"Acid Nigrosine"	o stain at first, later the C	C stain violet very rapidly	L stain dark violet	L stain dark violet

Plant	*Cynodon Dactylon*	*Dactylis glomerata*	*Dahlia variabilis*	*Erigeron canadensis*
Pollinating	June–Sept.	May–June	Sept.–Oct.	Aug.–Sept.
Size	30–38 μ	24 × 28–32 × 39 μ	28–35 μ	16–22 μ
Shape and marks	s O^1 L; S smooth; C granulated	e O^1 L o^n; S smooth; C coarse	s O^{12-20} L; S sharp spines; oil drops	s O^3 L; S spiny
Color	Dirty yellow	Grayish	Yellow	Yellowish gray
Sulphuric acid	Orange–light brown–yellow	Yellowish–pinkish–purple	Orange–light brown–colorless	Light pinkish–yellow
Nitric acid	Yellow–light brown; C swell a little	Yellowish–colorless; C swell and creep out	Greenish yellow–light yellow–colorless; C swell a little	Light yellow–colorless
Hydrochloric acid	Light yellow–colorless	Yellowish; E greenish yellow; I bright red-brown; O greenish yellow	Golden–yellow–light brown; S oil drops	Light yellow–colorless
Iodine water	Brown; St black	Yellow–golden; St black	C brown; PW brown; St black	Light brown; no starch
"Lugol's solution"	As in Iodine water	As in Iodine water	As in Iodine water	As in Iodine water
Ammonia water	Light yellow	Colorless; C swell; P violet–purple	Light brown	Greenish yellow–yellow
Sodium hydroxide	Yellow; grains swell; O swells, appears very distinct; PW orange	C and E yellowish, swell; P bright red-brown; O distinct	Bright red–orange–light brown–yellow; P swells	Lemon–greenish yellow–colorless
Potassium hydroxide	As in sodium hydroxide; O does not swell	As in sodium hydroxide	As in sodium hydroxide	Lemon–greenish yellow
"Acid Nigrosine"	L stains dark violet	L stains at first, later the P	L stain dark violet	L stain at first slowly, later the C

Plant	*Festuca elatior*	*Fraxinus americana*	*Gleditschia triacanthos*	*Helianthus annuus*
Pollinating	June–July	Apr.	May	July–Sept.
Size	23–30 μ	21 × 25–24 × 32 μ	28 × 32–42 × 46 μ	30–40 μ
Shape and marks	s O^1 L; S smooth; C coarse	e O^{3-4}; S smooth; C granulated	e O^3 L; S fine-granulated	s O^3 L; S sharp-pointed spines; oil drops
Color	Grayish	Brown	Light greenish yellow	Dirty yellow
Sulphuric acid	Colorless; E pinkish–purple	Greenish yellow; O distinct	Golden–colorless; P yellow; E pinkish; O distinct	Lemon–greenish yellow; oil drops green–blue

Plant	*Festuca elatior*	*Fraxinus americana*	*Gleditschia triacanthos*	*Helianthus annuus*
Nitric acid	Colorless; C and PW swell; E dark blue; I cherry-colored	Yellow; P light brown; C swell and creep out	Greenish yellow; C swell three or four-fold	Light (pale) yellow; C swell a little
Hydrochloric acid	PW swells to double; P bright red-brown; I lemon-colored	Dirty yellow	Greenish yellow; C swell and creep out; P weak greenish yellow	Yellow (golden)-light (pale) yellow; grains swell and burst
Iodine water	C light brown; St black	Brown; St black	Yellow–chocolate colored; no starch; surroundings of pores not stained	Light brown; no starch
"Lugol's solution"	As in Iodine water	As in Iodine water	As in Iodine water	As in Iodine water
Ammonia water	Colorless; PW bright red-brown and lavender; O distinct	Greenish yellow; fine pores distinct	Greenish yellow–dirty yellow; P colorless	Lemon–colorless; grains swell
Sodium hydroxide	Yellowish; PW swells; P bright red-brown	Greenish golden; fine pores distinct	Lemon; P colorless	Bright lemon; L swell
Potassium hydroxide	C swell; P bright red-brown	Golden–light brown; C swell; fine pores distinct	Greenish yellow–light yellow; C swell and creep out	Lemon–colorless
"Acid Nigrosine"	L stain dark violet, later the C	Parts of C below the O stain dark violet	L swell and stain dark violet	L swell and stain dark violet

Plant	*Iva ciliata*	*Iva xanthifolia*	*Ligustrum vulgare*	*Liquidambar styraciflua*
Pollinating	Aug.–Oct.	July–Sept.	May–July	Apr.
Size	24–28 μ	14 × 17–17 × 21 μ	24–35 μ	35–42 μ
Shape and marks	s O^3 L; S spiny	e O^3; S spiny	p O^3; S smooth; C granulated	s o^n L; S smooth
Color	Grayish yellow	Grayish yellow	Yellow	Yellowish
Sulphuric acid	Lemon–light yellow	Lemon–light yellow; Str of PW distinct	Orange–red-brown–brown	Orange–light brown; P golden
Nitric acid	Light brown; C swell and creep out	Lemon; C swell and creep out	Greenish yellow–dirty yellow; C swell to double size and creep out	Yellow; grains swell; P brown glimmer; o distinct
Hydrochloric acid	Light yellow	Light yellow–colorless; P light pinkish	Light greenish yellow; C swell and creep out	Yellowish–light brown; P light brown
Iodine water	Light yellow; St black	Light brown, later dark brown; St black	Light brown; no St traceable	Yellow; St black
"Lugol's solution"	As in Iodine water	As in Iodine water	As in Iodine water	Golden–brown; St black

Plant	*Iva ciliata*	*Iva xanthifolia*	*Ligustrum vulgare*	*Liquidambar styraciflua*
Ammonia water	Lemon–light yellow–colorless; Str distinct	Yellow–colorless; grains swell; Str distinct	Greenish yellow–dirty yellow	Yellow; grains swell a little; o distinct
Sodium hydroxide	Lemon–greenish lemon; grains swell a little	Greenish yellow–light yellow–colorless	Greenish brown–greenish yellow	Light yellowish–colorless; grains swell
Potassium hydroxide	As in sodium hydroxide	Greenish yellow–colorless; Str distinct	Greenish brown–greenish yellow; P colorless; C swell	Yellow–greenish yellow; grains swell a little
"Acid Nigrosine"	L stain first, later C	Three dark violet cone-shaped stoppers from the O to the centre	Places below the O stain dark violet	Whole grains stain dark violet

Plant	*Lolium perenne*	*Medicago sativa*	*Melilotus alba*	*Morus alba*
Pollinating	May–June	May–Oct.	May–Oct.	Apr.
Size	$24 \times 31–32 \times 39\ \mu$	$31 \times 35–42 \times 45\ \mu$	$20–28\ \mu$	$17–21\ \mu$
Shape and marks	e O^1 L; S smooth; C granulated	e O^3 L; S small reticulations; C granulated	t O^3 L; S cone-shaped projections from pores; C granulated	s O^2 L; S smooth; C coarse
Color	Yellowish	Grayish yellow	Greenish yellow	Light gray
Sulphuric acid	Light yellow–light brown; O distinct	Pinkish yellow–light brown–grayish; PW yellow	Yellow–light lemon–light yellow	Light brown
Nitric acid	Lemon–violet–purple; P swells	Light brown; C swell; grains burst; PW yellow	Light yellow	P colorless; E pinkish–purple
Hydrochloric acid	Grains swell and burst	Colorless; C swell to double size and creep out	Colorless	C swell and creep out; E light pinkish
Iodine water	Yellow; no St	Brown; no St	Brown; PW yellow; no St	Yellow–brown; St black
"Lugol's solution"	Yellow; P bright red-brown	As in Iodine water	As in Iodine water	Brown; P light brown; St black
Ammonia water	No change	Light yellow; O distinct; grains swell	Lemon–light yellow drops in the C	I pinkish-purple
Sodium hydroxide	Yellow; P bright red-brown; granules very distinct	Greenish yellow–dirty yellow	Lemon–colorless; C swell to double size and creep out	Yellow–colorless; C swell; Str distinct
Potassium hydroxide	Yellow; P red-brown, later light brown; granules distinct	Pale yellow; grains swell threefold and burst; PW chocolate-colored	As in sodium hydroxide	As in sodium hydroxide
"Acid Nigrosine"	L stains dark violet	L stains dark violet	L stains dark violet	At first the L of the O stain; later the P

Plant	*Panicum anceps*	*Phleum pratense*	*Pinus austriaca*	*Plantago lanceolata*
Pollinating	July–Sept.	June–Aug.	May	May–Sept.
Size	30–38 μ	25 × 31–33 × 35 μ	31 × 50–50 × 70 μ; without air-sacs, 31 × 40–38 × 55 μ	20 × 28 μ
Shape and marks	s O^1 L; S smooth; C granulated	e O^1 L; S smooth; C granulated	e O^2 L? S two air-sacs; C granulated	s O^{12} L; S smooth; C coarse
Color	Yellowish gray	Yellow	Light yellow	Yellowish gray
Sulphuric acid	Light brown–orange–golden; PW golden	Light yellow	Orange–flesh-red; P yellow; air-sacs later flesh-red	Orange–pinkish–colorless; PE golden
Nitric acid	Colorless; C clear up	Yellowish–colorless; grains swell to double size	Yellow; P lemon	Golden–yellow; P colorless; E red-brown; L swells
Hydrochloric acid	C colorless	No color reaction; C swell and creep out	C light dirty brown; grains swell to double size	Light red-brown–light brown–colorless; E red-brown; C swell
Iodine water	C dark brown; PW red-brown; St black	Yellow–golden; St black	Lemon–greenish yellow; St black	Golden; St black
"Lugol's solution"	As in Iodine water	Brown; St black	Light brown; St black; grains swell a little	Greenish yellow; St black
Ammonia water	No change	No change	Lemon–dirty yellow	Greenish yellow–colorless; P bright red-brown; O distinct
Sodium hydroxide	Yellow–pale yellow	Light yellow; Str distinct	Yellow; the air-sacs show the color reaction later	Grayish yellow; P red-brown; L swell
Potassium hydroxide	Yellow	No color reaction; O distinct	As in sodium hydroxide, but the color greenish yellow	As in sodium hydroxide
"Acid Nigrosine"	L dark violet	At first the L stains dark violet, later the whole grain	No distinct reaction; after a time the air-sacs stain	L stains dark violet

Plant	*Plantago major*	*Platanus occidentalis*	*Poa pratensis*	*Polygonum persicaria*
Pollinating	June–Sept.	May	May–Sept.	Aug.–Sept.
Size	20–25 μ	20–34 μ	31–37 μ	28–53 μ
Shape and marks	s O^6 L; S smooth; C coarse	t O^3; S smooth; C coarse	s O^1 L; S smooth; C coarse	s O^n L; S hexagonal reticulations; C granulated
Color	Light yellowish	Dirty yellow	Greenish yellow	Light yellow
Sulphuric acid	Lemon–colorless	Lemon–light brown; PW yellow	Orange–yellowish–brown	Greenish yellow–lemon–light brown; surface markings distinct
Nitric acid	Yellow (weak)–colorless	Light brown; C swell	Light yellow; E bright red-brown; grains swell	No color reaction, C swell and creep out; reticulations very distinct
Hydrochloric acid	Colorless; grains burst	Lemon; no change	Light brown; P and E bright red-brown	No color reaction; Str distinct

Plant	*Plantago major*	*Platanus occidentalis*	*Poa pratensis*	*Polygonum persicaria*
Iodine water	Dark brown; O colorless; St black	Brown; very fine and small starch grains which stain black	Light brown; no St	Light brown–greenish yellow; St black
"Lugol's solution"	As in Iodine water	As in Iodine water	Brown; no St	As in Iodine water
Ammonia water	No change	Lemon–dirty yellow; C swell a little	Light yellow; P bright red-brown	Greenish yellow
Sodium hydroxide	Light yellow	Pale yellow–colorless	Light yellow; P and E bright red-brown	Greenish yellow
Potassium hydroxide	Colorless	Lemon; C swell and creep out	As in sodium hydroxide	Greenish yellow–dirty yellow
"Acid Nigrosine"	L stains dark violet, later the C	Places below the O stain dark violet; later C stain	L stains dark violet; later C stain	L stain dark violet

Plant	*Populus balsamifera*	*Pyrus Malus*	*Quercus alba*	*Quercus coccinea*
Pollinating	Mar.	May	May	May
Size	28–40 μ	34–35 μ	28–34 μ	24–35 μ
Shape and marks	s o^n; S fine-granulated	t O^3; S cone-shaped projections from pores; C coarse	s O^3 L; S cone-shaped projections from pores	tO^3 L; S cone-shaped projections from pores; C coarse
Color	Yellow	Yellowish gray	Yellowish	Dirty yellow
Sulphuric acid	Yellowish green–pinkish; P bright yellow	Yellow–lemon–dirty yellow; PW lemon	Orange–red-brown; C yellow	Red-brown–light Indian red
Nitric acid	No reaction	Light yellow	Lemon–light yellow–colorless; C swell threefold and creep out	Lemon–light yellow–colorless; C swell threefold and creep out
Hydrochloric acid	Greenish yellow–colorless, transparent	Colorless; C swell to double size and creep out	Yellow–lemon–greenish yellow	Light yellow; PW darker; O colorless; C swell a little
Iodine water	C brown; St black; I red-brown	Brown; St black	C brown; PW yellow; very few small starch grains, which stain black	Brown; no starch
"Lugol's solution"	As in Iodine water	As in Iodine water	As in Iodine water	As in Iodine water
Ammonia water	PW swells and shows the layers	Colorless	Greenish lemon–greenish yellow	Yellow–lemon–dirty yellow
Sodium hydroxide	No change	Lemon–yellowish; C swell a little	Golden; PW light brown; O colorless	Lemon–dark greenish yellow; PW light brown; O colorless
Potassium hydroxide	Light yellow; grains burst	Lemon–yellowish–colorless	Golden–lemon–yellow; C swell a little; globoids distinct	Lemon–light yellow; C swell a little
"Acid Nigrosine"	C dark violet; PW light violet	Places below the O stain dark violet	L stain dark violet	L stain dark violet, later the places below the O; projections light violet

Plant	*Quercus rubra*	*Robinia pseudacacia*	*Rudbeckia laciniata*	*Rumex acetosella*
Pollinating	May	Apr.–May	Aug.–Sept.	May–Aug.
Size	24–35 μ	28–41 μ	20–25 μ	21 × 24–24 × 28 μ
Shape and marks	s O^3 L; S smooth; C coarse	t O^3 L; S fine-granulated	s O^3 L; S spiny	e O^4; S smooth; oil drops; C coarse
Color	Dirty yellow	Grayish yellow	Yellow	Yellow
Sulphuric acid	Red-brown–light brown	Golden–colorless; P yellow; E light pinkish	Lemon–greenish lemon; PW bluish green	Orange–light purple
Nitric acid	Yellow–light yellow; grains swell and burst	C swell four or five-fold and creep out	Colorless; grains swell a little	Colorless; C swell a little and part creeps out
Hydrochloric acid	Light yellow; C swell	No color reaction; C swell and creep out	Light yellow; Str distinct	Colorless; P yellowish
Iodine water	Light brown; no starch	Light brown–dark brown; St black	Brown; no starch	C yellow; P light brown; St black
"Lugol's solution"	As in Iodine water	Light brown–red-brown; very small starch grains stain black	As in Iodine water	C and P light brown; St black
Ammonia water	Lemon–greenish yellow–dirty yellow	No change	Light yellow–colorless	Grains shrink; Str of P and O distinct
Sodium hydroxide	Golden	Yellow; grains swell and burst	Lemon–greenish yellow–dirty yellow	Yellowish–colorless; S warty
Potassium hydroxide	Golden	Yellow; C swell and creep out	As in sodium hydroxide	Grains swell; S warty
"Acid Nigrosine"	O stain dark violet, later the places beneath the O	O stain dark violet, later the places beneath the O	L stain dark violet	O stain light violet very slowly

Plant	*Solidago canadensis*	*Taraxacum officinale*	*Trifolium pratense*	*Typha latifolia*
Pollinating	Aug.–Oct.	All year	Apr.–Nov.	June
Size	15 × 21–18 × 24 μ	35–50 μ	28–41 μ	35 × 42–38 × 45 μ
Shape and marks	e O^3 L; S obtuse spines; oil drops	s O^{12-20} L; S short blunt spines; oil drops	s O^3 L; S cone-shaped projections from pores	s O^1 L; pollen grains always in aggregations; S smooth
Color	Yellowish	Golden	Grayish	Yellow
Sulphuric acid	Greenish yellow–very light brown	PW purple; oil drops blue	Yellowish	Orange–light brown–light yellow; P light yellow; C light pinkish
Nitric acid	Colorless; C swell and creep out	Light yellow–colorless; C swell and creep out	Light yellow; C swell and creep out	Yellow; C swell and creep out
Hydrochloric acid	Lemon–dirty yellow	C swell; grains burst	C swell and creep out; no color reaction	As in nitric acid

Plant	*Solidago canadensis*	*Taraxacum officinale*	*Trifolium pratense*	*Typha latifolia*
Iodine water	Brown; no starch	Brown; no starch traceable; oil drops bluish green	C brown; no starch traceable	Golden; St black
"Lugol's solution"	As in Iodine water	As in Iodine water	As in Iodine water	As in Iodine water
Ammonia water	Colorless	Pale yellow; grains burst	No change	Golden
Sodium hydroxide	Greenish yellow; Str distinct	Lemon–dirty yellow	Yellowish; C swell and creep out	Golden–light yellow; Str of PW distinct
Potassium hydroxide	Light yellow; Str distinct	Pale yellow	C swell and creep out	As in sodium hydroxide
"Acid Nigrosine"	L stain dark violet	After a long time the O take the color	L dark violet; projections light violet	L stains dark violet

Plant	*Ulmus americana*	*Xanthium spinosum*	*Zea Mays*	
Pollinating	Mar.–Apr.	Aug.–Sept.	June–July	
Size	25–35 μ	22–28 μ	70 $\times$ 75–85 $\times$ 88 μ	
Shape and marks	p O^5 L; S smooth; C fine-granulated	s O^3 L; S smooth; C coarse	e O^1 L; S smooth; C granulated	
Color	Greenish yellow	Light brown	Light yellowish	
Sulphuric acid	Orange–light yellowish–colorless; PE distinct (Str)	Greenish yellow–brown	Yellow–golden–red-brown; surroundings of the O light yellow	
Nitric acid	Lemon–greenish yellow–colorless; Str of PW very distinct	Light yellow	Light yellow; C swell; O distinct	
Hydrochloric acid	Orange–yellow	Greenish yellow; Str of PW distinct	Yellow–lemon–grayish yellow; C swell; O golden	
Iodine water	Weak yellowish; no starch	Light brown; no starch	C light brown; St black; PW bright red-brown	
"Lugol's solution"	Dark brown, no starch; PE light brown; O distinct	Brown; no starch	As in Iodine water	
Ammonia water	Golden–greenish yellow; O and PW distinct	No change	Grayish yellow; grains swell; O distinct	
Sodium hydroxide	Golden; C swell	Lemon; I red-brown; Str of PW distinct	Yellow–lemon	
Potassium hydroxide	Golden	As in sodium hydroxide	Yellow–lemon; C coarse; P red-brown; O lemon	
"Acid Nigrosine"	L stain dark violet	O and parts of C below stain dark violet	O stains dark violet; PW stains later	

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